

Emission of Polycyclic Aromatic Hydrocarbons and Their Carcinogenic Potencies from Cooking Sources to the Urban Atmosphere

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Traffic has long been recognized as the major contributor to polycyclic aromatic hydrocarbon (PAH) concentrations. However, this does not consider the contribution of cooking sources of PAHs. This study set out, first, to assess the characteristics of PAHs and their corresponding benzo[*a*]pyrene equivalent (B[*a*]P_{eq}) emissions from cooking sources to the urban atmosphere. To illustrate the importance of cooking sources, PAH emissions from traffic sources were then calculated and compared. The entire study was conducted on a city located in southern Taiwan. PAH samples were collected from the exhaust stacks of four types of restaurant: Chinese, Western, fast food, and Japanese. For total PAHs, results show that the fractions of gaseous PAHs (range, 75.9–89.9%) were consistently higher than the fractions of particulate PAHs (range, 10.1–24.1%) in emissions from the four types of restaurant. But for total B[*a*]P_{eq}, we found that the contributions of gaseous PAHs (range, 15.7–21.9%) were consistently lower than the contributions of particulate PAHs (range, 78.1–84.3%). For emission rates of both total PAHs and total B[*a*]P_{eq}, a consistent trend was found for the four types of restaurant: Chinese (2,038 and 154 kg/year, respectively) > Western (258 and 20.4 kg/year, respectively) > fast food (31.4 and 0.104 kg/year, respectively) > Japanese (5.11 and 0.014 kg/year, respectively). By directly adapting the emission data obtained from Chinese restaurants, we found that emission rates on total PAHs and total B[*a*]P_{eq} for home kitchen sources were 6,639 and 501 kg/year, respectively. By combining both restaurant sources and home kitchen sources, this study yielded emission rates of total PAHs and total B[*a*]P_{eq} from cooking sources of the studied city of 8,973 and 675 kg/year, respectively. Compared with PAH emissions from traffic sources in the same city, we found that although the emission rates of total PAHs for cooking sources were significantly less than those for traffic sources (13,500 kg/year), the emission rates of total B[*a*]P_{eq} for cooking sources were much higher than those for traffic sources (61.4 kg/year). The above results clearly indicate that although cooking sources are less important than traffic sources in contributing to total PAH emissions, PAH emissions from cooking sources might cause much more serious problems than traffic sources, from the perspective of carcinogenic potency. **Key words:** benzo[*a*]pyrene equivalent concentration, cooking sources, polycyclic aromatic hydrocarbons, traffic sources. *Environ Health Perspect* 111:483–487 (2003). doi:10.1289/ehp.5518 available via <http://dx.doi.org/> [Online 30 October 2002]

Polycyclic aromatic hydrocarbons (PAHs) are one of the first identified airborne carcinogenic pollutants containing two or more aromatic rings that are fused together in different arrangements (1). PAHs and derivatives are associated with the incomplete combustion of organic material arising partly from natural combustion such as volcano eruptions or forest fires, but most emissions arise from anthropogenic activities such as the burning of gasoline in motor vehicles, residential heating, home cooking, and industrial production activities (1). In the past 30 years, many studies have suggested increased risk for certain cancers in cooks and other food-service workers (2–7). Because of this, many researchers have emphasized investigating PAH compositions in indoor air resulting from cooking processes. For example, Rogge et al. (8) found that the use of natural gas for cooking would increase the PAH concentrations in indoor air. Siegmund and Sadtler (9) found that PAH concentrations contained in hot cooking oil fumes (range, 1.08–22.8 µg/m³) were higher than those in an office room where 96 cigarettes were consumed within 6 hr (1.2 µg/m³). In

particular, van Houtd et al. (10) suggested that the cooking process was the most important contributor to the total mutagenic activity of indoor air. However, canopy hood ventilation has been widely used for cooking sources in many urban areas. Therefore, it can be expected that most PAHs emitted from cooking sources could be exhausted to the urban atmosphere. Many researchers have suggested that traffic is the major contributor to PAH concentrations in the atmosphere of urban and suburban areas (1). In one study, Harrison et al. (11) indicated that road traffic accounted for 88% of ambient benzo[*a*]pyrene at an urban location in Birmingham, United Kingdom. But to our knowledge, this estimate does not consider the contribution of cooking sources and hence warrants further investigation.

In this study we first focused on investigating the contents of PAHs that were emitted from stacks of four types of restaurants: Chinese, Western, fast food, and Japanese. Then, PAH emissions from home kitchen sources were estimated according to emission data obtained from Chinese restaurants. In addition, several PAH compounds have been

classified by the International Agency for Research on Cancer (12) as “probable” human carcinogens (2A) or “possible” human carcinogens (2B). Therefore, the carcinogenic potency associated with PAH emissions from various cooking sources were also estimated. In this study, we assumed that PAH emissions from both restaurants and home kitchens represented those emitted from all cooking sources. To assess the effect of cooking sources on PAHs emitted into the urban atmosphere, we compared the above-estimated PAH emissions with those emitted from traffic sources in the same city by directly using the emission data presented in our previous studies (13–15).

Materials and Methods

Sampling strategy. In this study, a city (area, 2,016 km²; population, 1,104,682) located in southern Taiwan was selected. According to the statistical data provided by the city government, the city contained 862 restaurants, including 743 Chinese, 88 Western, 20 fast food, and 11 Japanese. However, because of both cost and manpower, only 10 restaurants (4 Chinese, 2 Western, 2 fast food, and 2 Japanese) were randomly selected for this study. Table 1 lists the main cooking methods, types of food oil used, mean food oil consumption rates and cooking time for the total serving of lunch (or dinner), the stack diameters, and the mean stack outlet velocities and temperatures.

During the cooking period for lunch on the sampling day, we collected three PAH samples from the stack of each selected restaurant. We used a PAH sampling system (PSS; Li-Teh Co., Kaoushing, Taiwan) comparable to that specified by modified method 5 (16) for sampling semivolatile organic material. This system also has been widely used for collecting PAH samples from various industrial stacks (17–20). The sampling system was equipped with a sampling probe, cooling device, glass cartridge, pump, flow meter, and control computer. Each PAH sample was collected isokinetically from the stack, with a

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